SPARK

REPORT

STRATEGIC
PLANNING
FOR
APPLIED
RESEARCH
AND
KNOWLEDGE

Science
Council of
British
Columbia

OPPORTUNITIES FOR THE APPLICATION OF SCIENCE AND TECHNOLOGY TO THE AGRICULTURE AND FOOD SECTOR IN BRITISH COLUMBIA

Executive Summary of the Report

and

Recommendations

to the

Science Council of British Columbia

following the

Agriculture and Food Sector Forum

by the

Agriculture and Food Sector
Planning Committee

of the

Science Council of B.C.

May 1988

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AND FOOD SECTOR PLANNING
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SCCTTE/6

"Agriculture has made the transition from a resource-based industry to a science-based one...technological innovations are crucial to enable the American farmer to compete in the world's agricultural market place for both U.S. and world-wide markets, and are crucial to enable the nation to realize the economic potential of plants and livestock as annually renewable sources of wealth." (Dr. Howard Schneiderman of the Monsanto Co., as reported in U.S.D.A. 1987).

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EXECUTIVE SUMMARY
of the
COMMITTEE REPORT

Introduction

This report presents the findings of the Agriculture and Food Committee of the Science Council of British Columbia on the opportunities for Science Council to support economic development in B.C. over the period 1988 through the year 2000 by the application of science and technology to the agriculture and food sector in British Columbia.

For the purposes of the review reported here, the agriculture and food sector was defined as

> "That part of the B.C. economy embracing sustainable agriculture, horticulture, and aquaculture, including food production from plants, livestock, poultry, and fish; and the production of beverages, natural fibres, ornamental plants and flowers; and the supplying of inputs to, and the processing and distributing the products of these activities".

The Agriculture and Food Sector in British Columbia is a mature and stable component of the B.C. economy. It represents about $1.6 billion, or 3.7 percent of provincial Gross Domestic Product, per year. Agricultural production utilizes about 10.7 million hectares of land. This is about 11.5 percent of the provincial land base. Much is crown land used for cattle grazing. There are about 19,000 agriculture farms situated on about 2.4 million hectares of land, and about 500 aquaculture (both shellfish and finfish) operations. There are about 6,000 licensed fishing vessels in operation in B.C.

The Agriculture and Food Sector in British Columbia as defined above employs about 58,000 people; about 31,000 in agriculture, about 6,500 in fisheries and about 20,000 in food processing. Additional people work in food service establishments and in food and beverage wholesaling and retailing B.C. Total employment in food, beverage, fibre and horticulture production, processing and distribution is estimated to be about 166,500 people, or about 13 percent of the work force in B.C.

Present Status of Science and Technology in the Sector

Agriculture and food production have developed into sophisticated industries with dependence upon rapid acceptance of innovative technology for maintenance of competitive position in Canadian and world markets.

It is estimated that about $30.2 million per year is currently spent on research and development in the sector. This is about 1.9 percent of provincial Gross Domestic Product. Of this amount, about $24 million per year, or 81 percent, is spent by Agriculture Canada at its four research stations in the province. The work at these stations is primarily long term research, the results of which are aimed at production agriculture and processing.

Research is also undertaken at the provincial universities and within industry. The amounts of the expenditures in these two areas total about $5.7 million per year. Funding is from federal, provincial, and private sources, including, in 1987, about $300,000 from the Science Council of B.C.

The situation in R and D in the sector can be summarized as follows.

i. Funding of agriculture and food research and development has shown a consistently high return on investment.

ii. The B.C. Ministry of Agriculture and Fisheries makes only small contributions to research and these are in support of the more traditional aspects of production agriculture.

iii. There is a relatively low level of industry funding for R & D in the sector although many segments of industry are willing to cooperate in, and contribute in kind to, research projects.

iv. The limited amount of discretionary provincial funding currently available for R & D in the sector dictates that it is practical to support only short-term research and that high risk proposals for technology development or transfer cannot be entertained.

v. There is minimal infrastructure for research in the private sector of B.C.'s agriculture and food industries. The deficiency is partly the result of the small scale of much of B.C. industry and of the "branch plant" syndrome.

vi. There has been a deterioration of the research infrastructure within the Faculty of Agricultural Sciences at The University of British Columbia, and probably at other B.C. universities, as a result of financial inability to replace obsolescent equipment. Operating grant funds are seldom adequate to provide for the capital expenditures on equipment and laboratory instruments.

vii. Innovations in the Agriculture and Food Sector are interrelated closely with activities in the areas of Aquatic Resources, Biotechnology, Manufacturing and Machinery, Information Technology and Energy.

Areas for Action by the Science Council

i. Improvement of production efficiency with emphasis on

   a. Biotechnology
   b. Pest and disease management technology

   These are innovative approaches for improving efficiency. Technologies will be applicable to B.C. agriculture but will also be marketable elsewhere in Canada and abroad - both the technology and the instruments.

ii. Development of high value products from agriculture commodities.

iii. More efficient food processing techniques and improved packaging, storage and distribution processes.

iv. Food safety, environmental protection and waste management.

Recommendations Regarding Actions to be Taken

i. Maintenance of the present Science Council of British Columbia Assistance Grants to Applied Research (AGAR) system with increased funding to enable more effective pursuance of research needed to develop new production and processing technologies and for technology transfer for its industrial exploitation.

ii. Establishment of a mechanism for increasing industrial R & D in B.C. relative to further processing and handling of agricultural products AND of inputs into primary agricultural production.

iii. Financial support for industrial testing of new equipment design, innovative plant procedures and new control instrumentation.

iv. The establishment of Science Council Centres of Collaborative Studies in new product development, pest management technology development, agriculture and aquaculture biotechnology, and environmental protection.

   These centres would bring together scientists from universities, government, and industry and research associates, graduate students, and postdoctoral fellows, from throughout the province to research, develop, and test new products and technologies in the designated area. As well, each centre would function as a repository of knowledge and a centre for the dissemination of knowledge.

Recommendations Regarding Actions to be Taken (continued)

These centres would be located at provincial universities. However, each centre might undertake and/or fund activity at other locations such as technology transfer work at industrial sites.

British Columbia is a geographically attractive location for industries. Increased active support for innovative industry by way of RESEARCH SUPPORT and ASSISTANCE IN THE INTRODUCTION OF NEW OR EXPERIMENTAL TECHNOLOGY should encourage the movement of industry to the province.

I. INTRODUCTION

This report presents the findings of the Agriculture and Food Sector Planning Committee of Science Council of B.C. on opportunities for Science Council's address of Agriculture and Food Production, Processing, and Marketing in B.C. over the period 1988 through the year 2000.

This report was requested by the Science Council of B.C.

The Science Council of British Columbia

The Science Council of British Columbia is an agent of the Crown in Right of British Columbia established by the Science Council Act (RSBC 1979. Ch 379.)

Mission

The mission of Science Council of B.C. is the identification and promotion of opportunities for economic development in B.C. by drawing on the science and technology community for creative applications of innovative science and technology (WMC 1987a).

Objectives

The Science Council has eight objectives. The one of relevance to this report is the second objective, and within this objective, the second part. The second objective is:

> "2. To develop, promote and participate in the implementation of specific sectoral plans for the application of science and technology.
>
> These plans to be developed by representatives of industry, research institutions and government and integrated into overall plans for science and technology." (WMC 1987a).

The work of the Agriculture and Food Sector Planning Committee and the preparation of this report has been undertaken in support of this second objective.

Report Terms of Reference

The Committee's terms of reference for this report were

> "To prepare a report on the opportunities for the Science Council of B.C. to assist the Application of Science and Technology to Agriculture and Food Production, Processing, and Distribution in British Columbia in the interests of economic development in B.C. over the period 1988 through the year 2000" (SCBC 1987A).

The definition of the agriculture and food sector adopted by the Committee for the report was:

> "That part of the B.C. economy embracing sustainable agriculture, horticulture, and aquaculture, including food production from plants, livestock, poultry, and fish; and the production of beverages, natural fibres, ornamental plants and flowers; and the supplying inputs to, and the processing and distributing the products of these activities."

Background

The fact that agriculture, in common with other industries, is increasingly sophisticated and scientifically based dictates that industrial and science policies are inseparable.

The policy of having a balance of representation from the science and industry communities on the sector committees of the Science Council is a recognition of the importance of dialogue between these communities for ongoing effectiveness of the push-pull mechanism between new discoveries and their exploitation by industry.

The continuum from pure research to applied research to product development does not operate automatically but must be deliberately nurtured and encouraged.

There has been a dramatic shift in the employment of people within the work force in the agriculture and food industry within the past 25 years. Whereas in 1961, 11.2 percent of the population were engaged in on-the-farm agriculture, by 1985 this figure had declined to 4.3 percent of the population (Canada 1969 and Agriculture Canada 1986). Impressive as the decline in the proportion of on-the-farm workers has been, however, it was more than matched by the increase in the numbers of people employed in industries peripheral to primary agriculture.

The farm-gate value of agricultural products accordingly is no longer a complete statement of the contribution of agriculture to the overall economy. The actual value in terms of employment in the associated industries and the monetary value added to agricultural products beyond the farm gate make agricultural-associated industries an important component in the B.C. economy - and a component that is relatively stable and serves as a buffer in the economy of a province where the more volatile forestry and mining industries are apt to receive greater public attention.

Strategies for the furtherance of the agricultural and associated industries, and for the support of research and technological advances for the advancement of these industries in the face of increasingly competitive domestic and international markets need to be directed toward two areas. On the one hand, the efficiency of primary production of plant and animal products needs to be improved; on the other hand there are opportunities for further processing leading to food products with considerable added value as well as for isolation or manufacture of chemical products with a variety of industrial and/or pharmaceutical applications.

Historically, the Science Council of B.C. has funded applied research in the agriculture and food sector. The Council has received applications in each competition for grants to investigate such matters as the feasibility of developing new instrumentation, new machinery, new management techniques, new methods of disease and pest control, new genetic stocks of animals and plants, novel physico-chemical processes, methods of environmental protection, and better methods of quality control.

An important characteristic that will probably be typical of future advances in the many industries related to agriculture is a high level of scientific or technological sophistication. A high degree of mechanization and high inputs of energy from fossil fuel have resulted in a modern primary agriculture that is energy and capital intensive rather than labour intensive. The development of industries peripheral to primary agricultural production has, as already mentioned, provided more employment opportunities. In developing policies for the agricultural industry and for the scientific support of the agricultural industry the entire package of primary agriculture and its associated industries need to be considered.

II. SIGNIFICANCE OF AGRICULTURE AND FOOD PRODUCTION, PROCESSING, AND MARKETING IN BRITISH COLUMBIA

The data in Table 1 provide an overview of the agriculture and food sector as defined for this report.

The total land used for production agriculture is about 10.7 million hectares. There are about 19,500 farms in B.C. This total includes fin and shell fish farms. In addition to the fish farms there are about 6,000 licensed fishing vessels in B.C.

There are about 320 food processing establishments in B.C.

Employment in the sector totals about 57,700 people with about one half those jobs in agriculture, about one third in food processing and about ten percent in primary fisheries.

The capital invested in the sector is estimated to be about $7.4 billion.

The value of farm cash receipts is about $1.0 billion per year. The value of fish landed is about $370 million, and the value of shipments of food and beverages from processing plants in B.C. is about $3.0 billion per year.

Contribution to GDP

In terms of contribution to Gross Domestic Product (GDP, a measure of all the economic activity in the province), the agriculture and food products subsector together with the fishing and fish products subsector constitute the third largest primary industry group in the province (after forestry and mining), representing about 3.7 percent of GDP (Table 2). This contribution comprises 1.3 percent from primary agriculture, 1.6 percent from food and beverage processing, and 0.8 percent from fisheries and fish processing. The agriculture and food sector as defined for this report involves more than this estimate includes. Therefore, the contribution of the sector is greater than this amount as this estimate does not include the service portion of the sector: the wholesale, retail, and food service subsectors.

Land Base

Agricultural production occurs in most locations in B.C. where the soils, climate, topography, and market circumstances make it feasible. However, given the mountainous nature of most of the province, and northerly latitudes in which B.C. lies, the total area of land falling into this category is quite small. Table 3 provides details.

TABLE 1: B.C. AGRICULTURE AND FOOD SECTOR 1986

LAND USE	
Total Area under Agriculture	10,733,963 hectares
NUMBER OF PRODUCTION UNITS	
Farms	19,567 *
Licensed Vessels	5,970
Processing Plants	321
EMPLOYMENT	
Agriculture	31,260
Fisheries	6,497
Processing	20,000
Total	57,757
CAPITAL INVESTMENT	
Agriculture	$6,488.2 million
Fisheries	$949.0 million
Total	$7,437.2 million
VALUE OF SALES	
Farm Cash Receipts	$1,064.4 million **
Landed Value-Fish	$372.2 million
Shipments-Processing	$3,012.0 million

Source:
B.C. Ministry of Agriculture & Fisheries, (1987E).

* Census farms, including 504 active aquaculture establishments. Aquaculture establishments comprise shellfish and finfish farms. B.C. Ministry of Agriculture (1988B)

** Includes aquaculture sales.

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TABLE 2: AGRICULTURE, FOOD AND FISHERIES' CONTRIBUTION TO B.C. PROVINCIAL GDP AT FACTOR COST 1984 (a)

	($ million)	Percent
B.C. Provincial GDP	44,348	100.0
Agriculture	572	1.3
Food and Beverage Processing	713	1.6
Fisheries (b)	160	0.4
Fish Processing	183	0.4
Total Agriculture and Fisheries	1,628	3.7

Source:
B.C. Ministry of Agriculture and Fisheries, (1987F).

Note:
a. Some contribution from wholesale activities in the Agri-Food sector is not accounted for in the above.
b. Includes a negligible amount of trapping.

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The total area of land in the province is about 93 million hectares. Of this amount, about 10.7 million hectares, about 12 percent, is used partially or wholly for production agriculture. Some of this area, about 2.4 million hectares, is principally in privately owned farms where it is used almost exclusively for agriculture. The rest, about 8.3 million hectares, is crown land upon which grazing permits and leases have been issued. The cattle industry in B.C. relies heavily on these crown land grazing permits and leases for summer feed. These latter lands are also used for forest production in many cases, and for recreational uses in some cases.

The amount of land actually cultivated for annual crop production in B.C. is about 650,000 hectares. This amount is about six percent of the land used for primary agricultural production but less than one percent of the total land area in the province.

The limited amount of land in B.C. suitable for agriculture creates a need for efficient usage of that land. Areas devoted extensively to crop production are found only in the Peace River Region and to a much lesser extent around Creston. Elsewhere in the province, arable agricultural land is found only in relatively small parcels and more intensive production methods are applied. Intensive livestock and poultry operations together with intensive fruit and vegetable operations characterize B.C. agriculture on these lands. Market conditions also mean that some agricultural production which is essentially landless; e.g. floriculture, nurseries, greenhouses, and mushrooms also occurs in B.C.

Employment

Commercial primary agricultural production in B.C. employs about 31,000 people (Table 4). Commercial primary fisheries production in B.C. employs about 6,500 people (Table 5). The processing of agricultural and fish products in B.C. employs another 20,000 people (Table 6).

Within the food and beverage processing subsector, food processing accounts for about 83 percent of employment. Beverage manufacture accounts for the other 17 percent (Table 7).

In addition to the above employment provided by the sector, there are other positions down and upstream of agricultural production and processing. The agricultural supply sector and the food retail and restaurant industries employ an additional number of British Columbians estimated to be more than double those in the agriculture and food sectors.

TABLE 3: LAND USE IN B.C. 1986

	(ha)	%
TOTAL LAND AREA (1)	92,973,000	100.0
AREA IN FARMS		
Improved Land		
Under Crops	570,843	0.6
Summerfallow	81,166	0.1
Total Cropland	652,009	0.7
Improved Pasture	206,428	0.2
Other Improved Land	41,831	.0
Total Improved Land	900,270	1.0
Total Unimproved Farm Land	1,510,790	1.6
TOTAL AREA IN FARMS (2)(a)	2,411,060	2.6
Total Non-Farm Grazing Land (3)(b)	8,322,903	9.0
TOTAL AREA INVOLVED PARTLY OR WHOLLY IN PRODUCTION AGRICULTURE	10,733,963	11.5

Source:
1. B.C. Ministry of Lands, Parks and Housing. (1985). Area of Province, less water area.
2. Statistics Canada, (1987A).
3. B.C. Ministry of Forests and Lands. (1987).

Note:
a. Does not include grazing on crown-owned range land used under per head grazing permits.
b. Utilized crown range, used under permit or lease. Assumes 1986 allocation constant at 1984 level. Does not include grazing permits on private lands.

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Table 4: B.C. COMMERCIAL AGRICULTURE, 1986

Capital Investment	$6,488.2 million
Number of Farms	19,567
Employment	31,260
Value of Production (a)	$1,064.4 million

Source:
1.B.C. Ministry of Agriculture & Fisheries, (1987E).

a.For details see Table 7.

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Table 5: B.C. COMMERCIAL FISHERIES, 1986

Capital Investment	$949 million
Licensed Vessels	5,970
Employment	6,497
Landed Value of Catch	($'000)
Salmon	$246,696
Herring	$63,105
Groundfish	$40,680
Shellfish	$21,534
Other	$161
Total	$372,176

Source:
1.B.C. Ministry of Agriculture & Fisheries, (1987E).

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Table 6: B.C. FOOD AND BEVERAGE PROCESSING, 1986

Number of Plants	321
Employment	20,000
Value of Shipments	$3,012 million

Source:
1.B.C. Ministry of Agriculture & Fisheries, (1987E).

Note: Food and Beverage processing includes fish processing.

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Table 7: FOOD AND BEVERAGE PROCESSING IN B.C., 1984

		Food	Beverage	Total
Number of Plants		287	33	320
Employment:	Number	14,430	2,962	17,392
	Percent	83.0%	17.0%	100.0%
Value of Shipments	($ million)	2,323.0	414.8	2,737.8

Source:
1.Statistics Canada, (1984).

Note:
Food industries include fish processors.
Beverage industries include alcoholic beverage producers.

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In total, the employment in the agri-food and beverage industries including the farm supply, food retail and restaurant subsectors is estimated to total about 166,500 people (Agriculture Canada, 1987D) or about 13 per cent of the 1.274 million people employed in B.C. (Bank of Canada 1987)

Agricultural Production and Value of Production

The total value of farm cash receipts in B.C. in 1986 was $1.0 billion (Table 8).

Measured in terms of farm cash receipts, the major products of agriculture in B.C. are those listed at the top of Table 8. These products are milk and cream, beef cattle and calves, poultry, fruits, and vegetables. Floriculture (cut flowers) and nursery crops, eggs and hogs are also significant. Intensive industries are generating more farm income than some traditional agricultural production. The floriculture and nursery trades for example rank above eggs and hogs, and the value of all grain and oilseed crops in B.C. combined is less than the value of potato shipments.

In addition to farm sales, farmers receive a portion of their income from crop and/or income insurance schemes and from government subsidies and transfer payments. Of total cash receipts on B.C. farms approximately 6.1 percent originate from sources other than sales.

Sector Multipliers

An economic multiplier measures the downstream effect on the economy of an autonomous increase in spending in a given sector. Economic multipliers for the agriculture subsector and for the food and beverage sector of the B.C. economy have been estimated by the B.C. Ministry of Economic Development (Table 9).

According to these estimates, an additional dollar spent in agriculture creates an additional 65 cents worth of economic activity in B.C. The total effect of an additional dollar spent in agriculture is therefore $1.65.

The effect of an additional dollar spent in the food and beverage processing subsector is about $3.10.

This second multiplier indicates that additional revenues to the food and beverage sector in B.C. generate economic activity in the province by an amount about three times the increase in the sector.

Table 8: B.C. FARM CASH RECEIPTS BY PRODUCT, 1986

RECEIPTS FROM SALES	($ '000)
Dairy Products (Milk and Cream sold off farm)	$230,155
Cattle and Calves	$161,983
Poultry	$102,291
Fruits	$95,939
Vegetables	$76,592
Floriculture & Nursery	$65,135
Eggs	$59,418
Hogs	$53,399
Miscellaneous Crops	$30,566
Potatoes	$21,974
Forest & Maple Products	$18,266
Miscellaneous Livestock	$9,297
Wheat	$6,163
Barley	$4,191
Clover & Grass Seed	$3,476
Canola	$3,153
Sheep and Lambs	$1,716
Oats	$639
Rye	$22
Hay & Clover	$4
Other Products	$10,750
TOTAL RECEIPTS FROM SALES	$955,129
SUPPLEMENTARY PAYMENTS	
Provincial Income Stabilization Program	$13,696
Dairy Supplementary Payments	$10,227
Deficiency Payments	$1,243
Supplementary Payments	$8,252
Wheat, Canadian Wheat Board Payments	$1,348
Oats, Canadian Wheat Board Payments	$17
Barley, Canadian Wheat Board Payments	$349
Western Grain Stabilization Payments	$5,400
Crop Insurance Payments	$17,844
Canadian Wheat Board Cash Advances	$4,214
Canadian Wheat Board Cash Advance Repayments	($2,958)
Deferred Grain Receipts	($2,233)
Liquidation of Deferred Grain Receipts	$2,908
Net Non-Grain Cash Advances	$1,472
TOTAL SUPPLEMENTARY PAYMENTS	$61,779
TOTAL CASH RECEIPTS	$1,016,908

Source: Agriculture Canada, (1987D). Table 2: Cash Receipts from Farming Operations

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Table 9: SECTOR MULTIPLIERS

Action/Impact	Impact on The Provincial Economy As Measured by Indicators	
1. A One Dollar Increase In Output in	Output ($)	GDP ($)
A. Agriculture	1.822	1.652
B. Food Processing	1.94	1.80
2. One Extra Job in	Impact on Provincial Employment	
A. Agriculture	1.4	
B. Food Processing	3.25	
3. $1 million spent in	Creates Employment for (# of jobs)	
A. Agriculture	6.861	
B. Food Processing	15.409	
C. Total (A+B)	22.27	

Source: B.C. Ministry of Agriculture & Fisheries (1987F, 1988A)

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Mature Industry

The agricultural and food industries in B.C. are mature industries. They supply markets in economically developed countries, primarily in Canada, and primarily in B.C., but also including the USA, the EEC, and some Pacific Rim countries. Characteristic of these markets is their relative insensitivity to price levels reflecting the fact that people in these countries do not generally buy significantly more food when food product prices are lowered. Most people in these countries already have sufficient food. A reduction in prices does not lead to higher food consumption.

In this environment, additional sales of B.C. agricultural products can only be obtained by exporting to other countries or by substituting for imported food products. In both cases, costs of production and costs of sales in B.C. must be similar to, or below, those of products supplied by other countries. This means there is a real need for the agriculture and food industry in B.C. to be competitive on at least a North American basis, and possibly more broadly around the world.

Some industries, such as dairy and poultry, have limited their production to just the amount of Canadian domestic sales at domestically established prices. Sales in these markets will only increase as fast as population, disposable incomes, and tastes and preferences for these products in Canada increase.

Interactions with Other Sectors

The agriculture and food sector has interactions with several other sectors.

With the Forest Sector

There is an overlap with forestry in the efficient use of extensive crown owned lands for both grazing and forestry.

With the Urban Sector

There are increasing interactions between the urban and rural sectors in B.C. The relatively small area of the province which has topography and climate suitable for agriculture and horticulture is the same land which, in many cases is preferred for human habitation and other urban uses. Conflict between urban developers and rural conservationists continues and seems likely to intensify. Food safety and environmental protection are other dimensions of the urban rural interface in B.C.

Agriculture has major interactions with the urban sector of the economy in several areas of the province. Most notable are the interfaces between urban and rural interests in the Lower Fraser River Valley, particularly the municipalities of Delta and Richmond, and in the Okanagan Valley; although the borders between urban and rural areas elsewhere in the province are also important areas of interaction.

With the Aquatic Resources Sector

There is an overlap with the aquatic resources sector in that the product of the efficient use of aquatic resources is food.

As well, the fish farming industry utilizes the animal feed manufacturing industry in the agricultural sector as the supplier of fish feeds.

With the Economy of B.C. Generally

The agriculture and food sector has competitive interactions with all other parts of the B.C. economy as it competes for workers and for finance, and, in some cases, for the basic resource of plant agriculture: land with suitable soils, topography, and climate.

III. EXISTING RESEARCH AND DEVELOPMENT RESOURCES FOR THE SECTOR

Overview

Traditionally, agricultural research in North America has been publicly funded. There are a number of reasons for this. In the first place there has been, and continues to be, a belief that if is a responsibility of government to ensure the food supply of its people. Secondly, primary agricultural production, although in its entirety constitutes a large industry, is made up of a great number of small, individual operations. Research conducted to improve productivity and efficiency, and to test and introduce new varieties or species of plants and animals for culture, has accordingly been perceived as appropriately directed to the overall progress of agricultural production for the ultimate benefit of the country as a whole. Increased benefits of improved agricultural practice are, over time, captured by the consumers rather than by the producers of food. It has, therefore, been regarded as appropriate that taxpayers, as consumers of food, pay for the agricultural research leading to this result.

Application of research findings has led to marked increases in the level of sophistication and degree of specialization of many sectors of agriculture. Not only is today's farm usually a highly specialized operation, producing often only a single major commodity, but it is further specialized in that it is dependent on auxiliary industries for many of the goods and services required for its activities.

The handling of agricultural products beyond the "farm gate" employs more people in transport, processing, packaging, storage, and marketing than are engaged in primary production.

The changing pattern in the distribution of activities associated with the chain of events from farm to market, all of which activities are based in agriculture, has increased the market capacity to capture the gains and recover the costs of research and development. At the same time, therefore, public involvement in research directed to non-farm activities tends to be lower and the private involvement to be higher.

The rationale for public support of agricultural research has developed an additional dimension in accordance with the new types of knowledge and technology needed for development of the agriculture industry in its modern and expanded form. Research support for encouragement of innovative development of the many off-the-farm industries associated with British Columbia agriculture is needed for similar reasons that research in aid of other industrial endeavours is supported, particularly in the initial developmental phases, by funding from the public sector.

Figure 1 provides an overview of the relationships between the parties presently involved in agricultural and food research in B.C., their sources of funds, the process of technology transfer, and the final application of new technologies in the agriculture and food sector in B.C. The parties undertaking research and development for the agriculture and food sector in B.C. can be grouped broadly in two categories: public and private institutions.

Public Institutions:

The major public institutions involved in research for the benefit of the agriculture and food sector in B.C. are Agriculture Canada and the universities, primarily The University of British Columbia.

Agriculture Canada's Research Branch:

The major public institution in agriculture and food sector research in B.C. is the Agriculture Canada Research Branch. This branch of the federal Department of Agriculture (Agriculture Canada) operates four research stations in B.C. These are located at Vancouver, Agassiz, Summerland, and Kamloops. There is a substation of the Kamloops station located at Prince George. Another station, located at Beaverlodge in the Alberta Peace River region also contributes knowledge and research experience relevant to the Peace River region of B.C.

Until recently, there was an Agriculture Research Station at Saanich on southern Vancouver Island. However, this facility now functions only as an Agriculture Canada quarantine station.

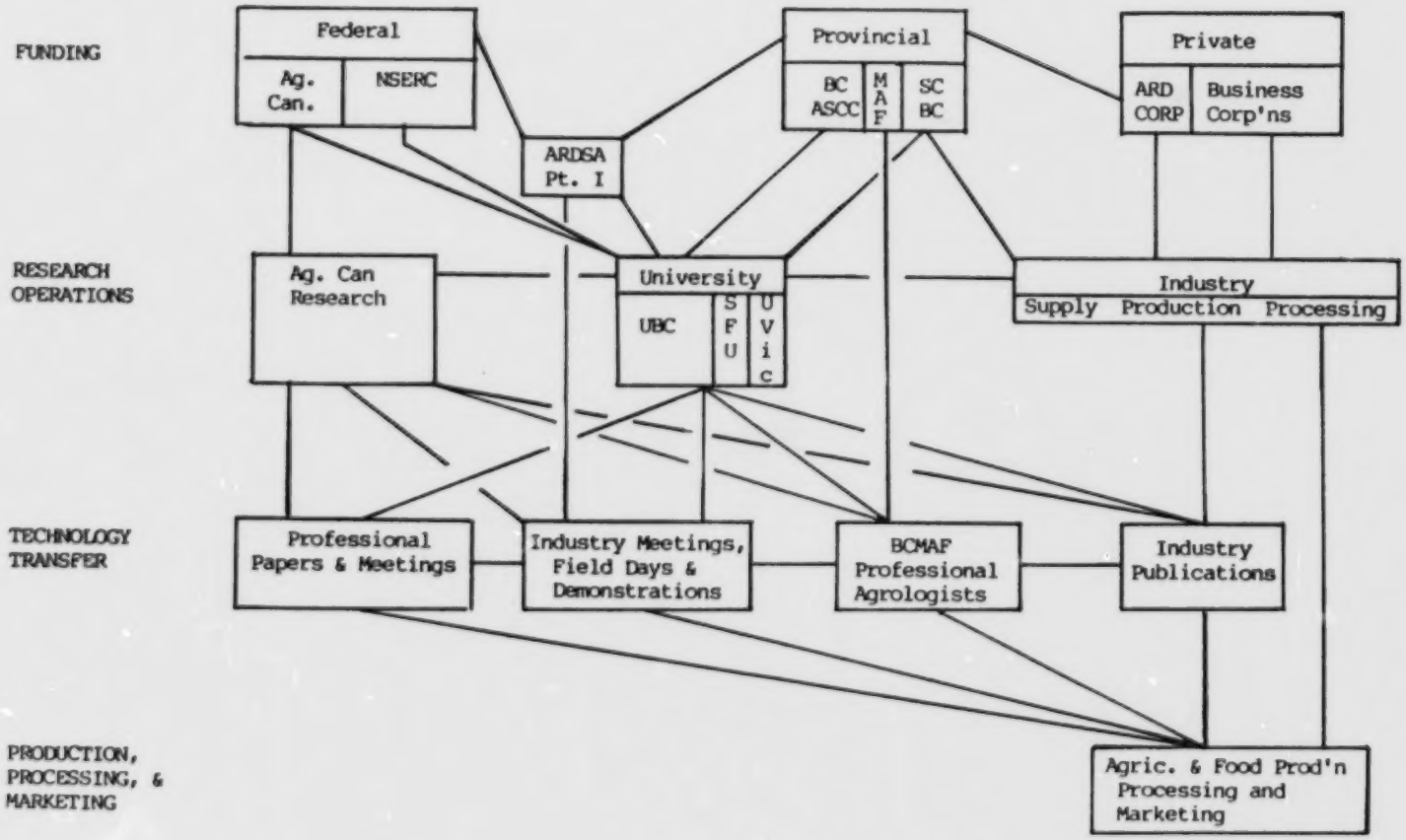
The philosophy of the Research Branch of Agriculture Canada is summed up in the following quotation:

> "The role of research in agriculture and food sector is to provide new knowledge leading to the development of new technology that will improve the profitability of the sector, resolve problems related to health and safety of producers, processors, and consumers, and ensure the long-term sustainability of the sector." (Ag. Can. 1987C. Part 1, p.1)

The University of B.C.

The University of B.C. has a Faculty of Agricultural Sciences which presently comprises 57 professional faculty, 60 research support staff, and about 136 graduate students involved in research related to agriculture and food. There is also some involvement in research related to agriculture and food from time to time in the Faculty of Science at the University of B.C.

FIGURE 1: STRUCTURE OF AGRICULTURE AND FOOD SECTOR RESEARCH IN BRITISH COLUMBIA, 1987.



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The other provincial universities, Simon Fraser University and The University of Victoria, also undertake a modest amount of research related to agriculture and food.

Industry Research and Development

Research and development is also undertaken by members of the private sector.

Technology testing is undertaken on farms and in the businesses of the sector.

Product development work is undertaken by such processing companies as the major dairies, canners and freezers, the manufacturer of refined sugar products, and by wineries and breweries in B.C.

Private research into fertilizers, farm machinery and equipment development, agricultural chemicals, pesticides and herbicides, and other "farm inputs" generally occurs outside the province, sometimes outside Canada.

Interactions Nationally

It appears that Agriculture Canada's Research Branch may be withdrawing from applied research and be emphasizing selected long term programs and cooperatively funded "research partnerships" (Aylard 1987 p.6, Ag. Canada 1987C Pt. 2. p.5).

Collaboration

There is frequent collaboration among scientists working in research in both public and private institutions in B.C.

Considerable collaboration occurs between Agriculture Canada research scientists and scientists in the three provincial universities. This collaboration is especially close between the scientists at the Agriculture Canada Vancouver Research Station and those at The University of B.C. The University of B.C. has the only Faculty of Agricultural Sciences in the province and the the Vancouver station is located on the campus. Further, some Agriculture Canada and Fisheries and Oceans Canada professionals are Honorary and Adjunct Professors of the UBC Faculty of Agricultural Sciences. Facilities of the Agriculture Canada and of Fisheries and Oceans Canada research stations, as well as the Research Laboratories, in B.C. are sometimes used for research purposes by PhD and MSc students, and others, mostly from UBC.

The B.C. Ministry of Agriculture and Food District Agriculturalists and District Horticulturists often seek advice from Agriculture Canada and the universities. They also make use of Agriculture Canada and the universities as a source of speakers and instructors for grower's organizations. However, the nature of technology transfer in the agricultural sector is changing and this creates an opportunity for the Science Council to support developments in new directions.

With the private sector, collaboration takes many forms. Advice has been given for example on control of lettuce aphids in the Cloverdale area; on the control of European wireworm in sweet and silage corn in the upper Fraser Valley; and on the pest and production problems in growing virus-free seed potatoes.

Funding

There are two sources of funding for research and development in the agriculture and food sector in B.C.: public sources and private sources. Table 10 provides estimates of the amounts of funding from each of the major sources, and of their relative magnitudes in 1987/88.

The major public sources of research and development funding in the sector are Agriculture Canada, the National Science and Engineering Research Council, and the Canada/British Columbia Agriculture and Regional Development Subagreement 1985-1990.

Agriculture Canada is the largest single source of research funds; about $24.4 million per year in 1987/88. Most of these funds are disbursed to its own research stations. However, some funding (about $160,000 in 1987/88) is made available to individual researchers at universities in B.C. through the Agriculture Canada Operating Grant program and through contract research.

The next largest block of public funding for research and development in B.C. is the National Science and Engineering Research Council; about $1.2 million in 1987/88.

The Agricultural and Regional Development Subsidiary Agreement (ARDSA) is a joint funding mechanism of Canada and the Province of British Columbia for agricultural development. Funds are provided by the two parties equally and the program is administered jointly by the provincial and federal departments of agriculture. Five million dollars over the five years to 1990 is available for technology development and technology transfer under Part I of the subagreement (Ag. Can. 1987C. Pt. 2, p. 5).

The is about $400,000 of funding available from B.C. Research sources.

The B.C. Ministry of Agriculture and Fisheries (BCMAF) supports research and development in the sector by at least two means: through BCASSC grants and through the Food Industry Development Program.

BCASSC (the B.C. Agricultural Services Co-ordinating Committee) provides funds to researchers in the Faculty of Agricultural Sciences at U.B.C. The amount of funding available is about $150,000 per year and it is allocated equally to the six departments in the Faculty.

Table 10: RESEARCH AND DEVELOPMENT FUNDING TO THE AGRICULTURE & FOOD SECTOR IN BRITISH COLUMBIA, 1987/88.

		$000	Per cent
A. FEDERAL			
Agriculture Canada			
Research (1)	$24,376		
Operating Grants (2)	$60		
Other (9)	$98		
Total Ag. Canada		$24,534	81.2%
NSERC (8)		$1,163	
Other federal departments (8)		$109	
TOTAL FEDERAL		$25,806	85.4%
B. FEDERAL AND B.C. PROVINCIAL			
ARDSA (3)		$1,000	3.3%
C. B.C. PROVINCIAL			
B.C. RESEARCH (12)		$400	
B.C.M.A.F.			
BCASCC (4)	$150		
Food Ind. Dev. Prog. (7)	$150		
Total BCMAF		$300	
SCBC (5)		$284	
TOTAL B.C. PROVINCIAL		$984	3.3%
D. PRIVATE INDUSTRY			
To The University of B.C. (8)		$523	
To B.C. Research (12)		$400	
B.C. fruit growers and shippers (9)		$300	
ARDCORP (6)		$250	
Other (10)		$969	
TOTAL PRIVATE INDUSTRY (11)		$2,442	8.1%
TOTAL FUNDING (Est.)		$30,232	100.0%

1. Ag. Can. 1987C, Part 2, p.11 (Tbl.2) less amount of (capital) expenditures on construction, Ag. Can. 1988B.
2. Derived from Agriculture Canada 1987B.
3. Agriculture Canada (1987C). Part 3, p.5.
   Funding 50/50 federal/provincial
   One half 1987/88 funding allocated to ARDCORP for tech. transfer (not shown below to avoid double counting)
4. B.C. Agricultural Services Coordinating Committee; Agriculture Canada, (1987C). Part 3, p.5.
5. Science Council of B.C., (1987B), p.30.
6. BCMAF. (1987B).
7. Ag. Finance Br. Food Ind. Dev. Prog. Source see 6.
8. UBC 1987. Underestimate; total for UBC only.
9. Agriculture Canada (1988A).
10. By remainder.
11. Estimate, see script.
12. B.C. Research (1988)

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The BCMAF Food Industry Development Program disburses a similar amount of money each year for product and process research and development in the food industry in B.C.

The Science Council of B.C. has contributed between $250,000 and $300,000 per year to applied research in the sector in recent years.

Total provincial sources provide about $1.0 million per year.

ARDCORP (the Agricultural Research and Development Corporation) is wholly owned subsidiary company of the B.C. Federation of Agriculture. ARDCORP has a commitment from the ARDSA for $500,000 to fund small technology transfer projects during the current fiscal year. Through this company, the membership of the Federation will also contribute about $250,000 for agricultural research and development in 1987/88.

Private industry in the sector undertakes both product and process research. Data for the research and development expenditures of this subsector are not readily available. However, if it is assumed that research and development expenditures in the subsector are about twenty five percent of the B.C. provincial average level of 0.6 percent of GDP, then total privately funded research and development expenditure in the food and beverage sector would be of the order of $2.4 million per year. Some of his amount is spent by industry in-house, some of it is provided to B.C. Research in Vancouver, some to The University of B.C., and to Agriculture Canada research stations.

The total amount of research and development funds available in B.C. annually is estimated to be about $30.2 million in 1987/88. This is about 1.9 percent of (1984) provincial GDP.

IV. THE AGRICULTURE AND FOOD SECTOR IN BRITISH COLUMBIA 1988 TO 2000

In this section, the Committee provides a summary of the major trends and developments anticipated to occur in the sector over the next twelve years. Against this background the opportunities for Science Council participation in the application of Science and technology to the sector will then be addressed.

Assumptions

The Committee starts by listing a number of critical assumptions.

1. The population of Canada will grow slowly over the period. Statistics Canada projects that the increase in the total Canadian population over the period will be about 8.4 percent, or about 0.6 percent per year. Similar projections for B.C. indicate a total increase of about 10.3 percent for the period or about 0.7 percent per year (Statistics Canada 1985B).

2. These increases in population will provide comparable small increases in the demand for food and beverage products in Canada and in B.C. over the period.

3. Disposable incomes (after tax dollars available for personal and family expenditure) are also expected to grow slowly in the period. A competitive wage and salary environment is anticipated and taxation is more likely to increase than decrease. Any increases in disposable incomes in the period are therefore expected to be modest.

4. Overall consumption of food per capita in Canada and in B.C. is expected to be flat. Within the overall trend, there will be some products which increase in popularity and sales and some which lose and fall away.

5. The food consuming public in Canada is expected to become more health conscious in future. This suggests a continuing trend towards consumption of fresh foods, particularly fruit and vegetables, and a continuing concern with the health hazards of contaminants of food products.

6. The business trading environment is expected to become increasingly competitive over the period. Part of this increase is expected to derive from the anticipated adoption by Canada of a "free trade" agreement with the USA. However, there is already evidence that markets for both goods and services in Canada are already becoming more competitive. As well, increasing agricultural productivity in some developing counties, particularly the People's Republic of China, and increased market competition from other country surplus disposal programs (in the USA and the EEC) are expected to be contributory factors to this increasingly competitive market environment in agriculture and food products.

Directions

1. More Competition

Against this background, it is the Committee's conclusion that it is more likely than not that the market environment for the agriculture and food sector in B.C. will be more competitive in the period considered than in previous years. This suggests a need for product innovation and increased efficiencies in all areas of agricultural production and in all areas of food and beverage processing, marketing, and sales.

Those lines of business endeavour in the sector which are already competitive will probably enjoy opportunities to grow in the period. Markets in the USA and elsewhere will be accessible at prices sufficient to cover Canadian costs.

For those lines of endeavour which are presently heavily protected, difficulties are expected in their ability to compete and loss of market share and/or revenues may result.

In all cases, existing businesses will need to be more innovative and/or more efficient to continue to survive. Increases in technical efficiency of production and processing are expected to be more significant than previously.

2. Food Safety

A second trend identified by the Committee was one towards greater concerns by consumers with food safety.

This trend is consistent with the Canadian pattern of a sufficient supply of food being provided from an increasingly controlled type of "manufacturing" and technologically sophisticated agriculture and food production system.

Modern agricultural and aquacultural practice is under constant criticism with respect to its effects on the environment. At the same time the safety of our foods is questioned because of possible contamination with environmental pollutants and because our foods are seen as containing increasing numbers of additives.

Many of the increases in yields of plant and animal production occurring in recent years have been made possible by more control of the production environment. Herbicides and pesticides control weeds and insect pests allowing plants and trees to grow more vigorously and more productively. Livestock and poultry are now often housed or confined on a continuous lifetime basis. (Hormones are used to stimulate growth and production. Chemicals and biochemicals are used to control disease and pests. Wastes are concentrated as a result of controlling production.)

Concerns are expressed by consumers over chemical and biochemical residues in foods and environmentalists are concerned about persistent chemical residues and about animal and poultry wastes polluting land and water. Livestock and bird welfare groups are also a factor influencing the regulatory environment for food production now, and in the future.

Historically, the Agriculture and Food Committee has generally viewed its mandate for funding research under the AGAR program as limited to the development of technology and of new products that will improve the B.C. economy and employment opportunities on a fairly short term basis.

The public awareness of industrial impact on environmental quality and its concern for food safety has been very much heightened during the last decade. It, accordingly, dictates that any program for industrial development should include consideration for environmental quality and food safety in order that any enterprise that is being furthered should have viability in the long term.

3. Environmental Protection

Several aspects of environmental protection have been identified by the Committee.

Land Degradation

One area of environmental concern is land degradation. This takes several forms. On some soils there are problems of deteriorating soil structure resulting from compaction by animals and mechanical equipment. On other soils there are erosion problems due to water or wind effects. Declining soil fertility and soil pH problems occur when soils are heavily cropped. Increases in these problems over time, lead to increasing costs of using these soils for food and fibre production.

Water Pollution

The use of highly soluble fertilizers associated with some types of contemporary agricultural production can, and does, lead to these chemicals reaching the the ground water. This pollution can give rise to pollution of streams, rivers, and lakes. The chemical pollution of the water can limit its usefulness as a source of municipal drinking water supplies and growths of weeds and other aquatic life can hinder if not destroy these water courses for recreational purposes.

Air Pollution

Pollutants from urban aggregations are increasingly influencing the atmospheric environment for agriculture, especially near major cities. Some climatologists have suggested that as a result of increasing contamination of the earth's atmosphere, surface

temperatures may rise by as much as 2.5 degrees Celsius within 25 years. Such a change in the environment would give rise to a need for major changes in the types and amounts of agricultural production in all areas of the world including in B.C.

4. Rural/Urban Interface

While it is expected that the population of B.C. will grow slowly over the study period, it is also expected that this population will continue to want relatively large amounts of land space for personal living. This suggests increasing amounts of presently rural land being converted to urban uses, especially for residential housing. There will be an increasing need for production agriculture in B.C. to occur or take place on a smaller land base.

5. Sales of Technology

There will be some products of agriculture and the food industry in B.C. which will not be able to be produced competitively in the study time period. In these cases, it is likely that the technology of their production, rather than their products, may be sold at export. This is already the case, for example, with high productivity dairy cattle. The cost of producing milk in B.C. is such that it is not presently possible to export B.C. made primary dairy products profitably. However, offspring of high producing cows and bulls, or embryos, or ova and/or semen representing superior genetic stock can be and are being sold profitably as a product of B.C. agriculture. It is expected that sales of technology of this type will increase in circumstances where the B.C. product itself is too costly to export profitably.

Sales of virus-free potatoes from B.C. to other provinces in Canada and also to the USA represent another form of sales of B.C. technology in the agriculture and food sector.

6. Market Niches

It is expected that, broadly speaking, the types and amounts of production agriculture and food and beverage processing presently occurring in B.C. will continue in the future. B.C. will continue to provide a substantial amount of the foods consumed in B.C. as at present.

Growth and development will however take place about the "edges" of existing production patterns. In the opinion of the Committee, the leading edges of this growth and development will be related to market niches which provide opportunities for B.C. producers to exploit unique natural conditions in the province for agriculture, food production, or food and beverage processing. High value food products and freshness as a quality in those products are both expected to be part of this area of emphasis.

7. Planning

There has been much consideration given to planning the output of agricultural and food production sector in B.C. over the last three years. The provincial and federal departments of agriculture, working with primary and secondary producers in the sector, and with farm input suppliers, have developed a series of commodity profiles, strategies, and plans for the sector. As well, work is continuing on a provincial plan and strategy and, at the federal level, there has been extensive review of research commitments to the sector as well as to production and development plans.

These profiles, plans, and strategies, to the extent they were complete at the time of the Committee consideration, have been reviewed for the Committee and have contributed to the assessment of needs and priorities for research and development listed below. (References to the individual commodity profiles, plans, and strategies are provided in the bibliography at the end of the report.)

V. NEEDS OF THE AGRICULTURE AND FOOD SECTOR FOR THE PRODUCTS OF SCIENCE AND TECHNOLOGY IN THE STUDY PERIOD

The needs of the agriculture and food sector in B.C. over the next twelve years fall into several areas.

Product Innovation

"Regardless of category, an industry must either innovate or perish. Either new products must be developed to replace those which are obsolete or mature and declining, or the related industry will simply cease to exist. Although this reality has been more obvious for other American industries, it also applies to American agriculture." (U.S.D.A. 1987).

As consumers are increasingly sufficiently well fed in developed countries, including Canada and within Canada, in B.C., they are expected to be increasingly selective and discriminating in their purchases of food. High quality will continue to be demanded. Freshness will also be important. Novelty will be valuable. New products and packaging and storage processes which maintain and extend fresh product shelf life will be necessary.

"In contrast to the situation for major commodities, international trade in high value agricultural products is increasing. The OTA (Office and Technology Assessment) reports that world trade in high value agricultural products, such as processed commodities and horticultural crops, now exceeds world trade in bulk agricultural commodities. Furthermore, the market value of trade in HVP's is projected to continue to grow significantly during the next few years..." (ibid.).

In particular the Committee notes the need to change direction towards trade in high valued products of agriculture and food industry.

Production Efficiency

The need for production efficiency derives directly from the need to compete profitably in available markets in B.C., in Canada, and at export. What is needed for the sector for the future are technologies which increase output per unit of input profitably across a wide front of agricultural and food production activity.

A major need in this area is for better disease and pest controls in crop and livestock production systems.

Food Safety

Efficient biologically controlled (not chemically controlled) processes are likely to be favored in future for the reasons of food safety. The development of these biological processes are likely to take precedence over continuing and new chemical processes.

Environmental Protection

Attention needs to be paid to soil conservation and to the maintenance of soil fertility in order that present levels of agricultural production can be maintained and, in the future, increased. New soil and water conservation technologies are needed.

The trend to increasing concentration of livestock and poultry populations in order to gain technical efficiencies of production has been mentioned above. Efficient handling of waste from these production facilities is expected to be an increasingly significant issue in the sector.

Processing and Distribution Efficiencies

There will be a continuing demand for technologies which improve the efficiencies of food manufacture (from agricultural products) and food and beverage processing in the province. High wage costs, low throughput, short (season) production runs, and long distances to small markets are all characteristics of the food processing and distribution sector in B.C. There is a need for processing machinery and equipment which can have multiple uses, processes which can be used with a variety of input materials, and for processes which are high yielding, and thus efficient.

Efficient transportation and storage of raw materials are issues with some commodities (vegetables and fruit).

Relative Importance

Some measure of the relative importance of these issues in the production agriculture portion of the sector can be gained from an analysis of research and development issues identified in the commodity strategy plans produced for the agriculture sector recently.

An analysis of 25 B.C. Agriculture Industry Commodity Plans (BCMAF 1987A) indicates that in 22 plans there is a need for market development; in 19 plans there is a need for better pest control; in 16 cases a need for innovations in methods of produce or product handling; and in 14 cases a need for new seed or plant variety development and testing and for assistance in production diversification and integration.

By contrast, a need for assistance with financing was only identified in three plans; a need for mechanization, in five plans; a need for soil and water management in six plans, and for health and nutrition research and development in six plans.

Interrelationships

Aylard (1987) identifies a need for stronger interrelationships between research scientists in B.C., and for increased sponsored research activity as two ways of raising levels of technology in the production phase of agriculture (p. 7).

A recent report indicates federal provincial agreement on need for research and development as an "engine" of the Canadian economy in future (Vancouver Sun 1987).

Technology Transfer

The area of technology transfer in agriculture was widely identified in the industry/BCMAF/AgCan studies as an area for improvement. There is a need for technology testing in the agriculture and food sector and a significant need for improved rates of technology transfer in all areas of agricultural production in B.C.

VI. EVALUATION OF PRESENT R & D CAPACITY TO MEET NEEDS

The Committee has reviewed the presently available capacity in the Agriculture and Food sector in B.C. to undertake and complete the kinds and amounts of research and development needed in the sector to the year 2000. The Committee's findings are as follows.

Long Term Research

The primary responsibility for long term research in the sector currently lies with Agriculture Canada. The universities also contribute to long term research.

It appears that support for applied research by Agriculture Canada is declining. There is an opportunity for Science Council of B.C. to make a significant commitment to long term agricultural and food research in the province focused on the issues identified above.

Applied Research

Those who undertake applied research in the sector are private companies, both big and small, using their own funds and grants from agencies such as Science Council and ARDSA. The funding for this part of R & D in B.C. is very modest and could increase substantially to attain significant levels.

Teaching and Training

The market for research scientists is an international one. Canada and B.C. must compete with the USA and with other countries to obtain and retain the services of the best research scientists. Adequate funding is an obvious requirement in this competition.

Training of research scientists is a similarly international activity. B.C. should play a part in this training. However, it should not be expected that scientists trained in B.C. will remain in B.C. throughout their professional lives. Investments made in the training of scientists in B.C. have to be seen in the light of a contributions to the international pool of talent. B.C. supplies some to, and draws some from, this pool.

The present Science Council Graduate Research, Engineering and Technology Scholarships (GREAT Awards) provide support for scientists and engineers to obtain advanced degrees at B.C. universities while working with an off-campus industry or agency.

Strengths

The strengths of the present R & D resource in the sector are:

1. There is a strong, publicly funded, long term research effort for the sector existing in the Agriculture Canada research stations in B.C. and in the research scientists at the province's universities. There are a great many well trained people in these institutions capable of providing some of the research and technological advances required in the sector over the study period.

2. Cooperation between the participants in both scientific research and technology transfer in the province is good.

3. Industry participants are willing to provide resources in kind (such as land for testing new varieties of crops and portions of growing crops for testing new disease and pest controls) to scientists and others for research purposes.

4. There is a need to develop research programs which allow individual scientists to work independently while still contributing to an overall program. The research programs should provide an "umbrella" for multifaceted integrated technical development which will service more than one industrial sector.

Weaknesses

The present weaknesses of the R & D resource in the sector are:

1. A lack of plant breeders' rights in Canada. Privatizing of the research activity, currently being suggested by Agriculture Canada in its requests for co-operative research and more industry participation in research, is likely only to proceed slowly, if at all, without the patent rights available to inventors in other areas of the economy. Without these rights, there is no mechanism by which the gains, and the costs of those gains, from R & D can be captured by those who incur them. Without this element of structure, much genetic research will remain in the public sector, possibly underfunded, for a long time.

2. There is very little formal funding of agricultural, fish, or food processing research in the sector by the B.C. Ministry of Agriculture and Fisheries. This is in contrast to the situation in the Ministries of Health, Education, Environment, and Forestry.

3. The infrastructure for scientific research at B.C. universities has deteriorated. Additional funding is needed to repair and maintain existing equipment and facilities, and with which to obtain state of the art, current technologies in support of current and future research.

4. The provincial mechanism for publicly funded technology transfer in production agriculture and horticulture has been depleted. The Regional Extension Service of the B.C. Ministry of Agriculture and Fisheries has suffered significant staff cuts over the last five years. This link in the technology transfer process is less effective than previously.

5. The present informal and personal cooperation occurring between universities and the staff of B.C. Ministry of Agriculture and Fisheries is a weak mechanism. This mechanism could be strengthened by the placement of Ministry personnel at the University of B.C. to better provide for and assist with the effective transfer of technology from the University to industry.

Trade Conditions

1. The recent international trade rulings made pursuant to the General Agreement of Tariffs and Trade (GATT) may lead to changes in certain portions of the sector. Notable in this regard are recent rulings regarding the exports of unprocessed fish from B.C. and the marketing policies of provincial liquor control boards in Canada, including B.C., in respect of the relative pricing of Canadian (B.C.) and European wines.

2. The "free trade" agreement by Canada with the USA is similarly expected to be the cause of some changes in some other parts of the industry. The major parties likely to be affected are the producers of supply managed agricultural commodities (milk and poultry products), some food and beverage processors (breweries, and processors of supply managed commodities), and those currently otherwise receiving considerable protection in domestic markets (wine grape growers and wineries).

VII. OPPORTUNITIES FOR SCIENCE COUNCIL ACTION IN THE PERIOD

Principles

The Committee is of the opinion that the opportunities for Science Council to have a significant impact on the economy of B.C. through its support of research and development in the agriculture and food sector over the period considered lie in the following areas:

1. Emphasis on improving market penetration, for example by improving packaging, storage techniques, form of preparation, product diversification and developing new products.

2. Emphasis on research that will improve productivity (not only at the farm level, but also throughout chain from input to consumer), including environmental and crop protection technologies.

3. Some of the best payoffs may exist in adapting/adopting technology developed elsewhere. The sector is diverse; each sub-sector is small in the international arena in which they increasingly compete. B.C. cannot begin to "cover the waterfront" in research - emphasis must be placed on results that can be applied to the specific B.C. situation. Selectivity and links to final application are key.

4. Attention should be paid to the way technology is adopted, and how the rate of adoption may be increased. For example, funding decisions on science and technology development ought to include consideration of how the technology will be transferred and adopted, and the eventual economic impact achieved.

5. With freer trade, B.C. will tend to concentrate on strengths. B.C. will put less emphasis and resources into endeavors that aren't competitive. Science and technology efforts should promote this movement rather than try to slow it. Research efforts should predominantly build on existing or natural advantages, particularly those natural advantages of geography and climate, and help lead the way to realizing the maximum advantage from broad market opportunities.

Actions

It will be noted that innovations in the Agriculture and Food sector are interrelated closely with activities in the areas of Biotechnology, Manufacturing and Machinery, Information Technology and Energy.

1. Improvement of Production Efficiency with emphasis on:

A. Biotechnology

"There now seems to be no question as to whether or not biotechnology will have a monumental impact on agriculture. The only questions seems to be: (1) when it will happen; and (2) who will lead in intl. (the initial) applications, and thereby reap the most benefits?" (USDA. 1987. Words in brackets added).

In the Committee's view, it would be very appropriate for Biotechnology to be selected as a long-term priority area. Agriculture (and horticulture) in B.C. has now developed to the stage of being a high-tech industry and this probably will become more pronounced in the future. Forestry would also benefit from this thrust. The scenario that is envisaged for the application of biotechnology in the animal area is as follows:

i) utilization of bio-engineered products such as growth hormone. This is the current stage. For instance, the Department of Animal Science (at UBC), along with other Universities and industry groups, is researching the benefits of growth hormone in dairy cows (an improvement of 15-20% in milk production is being obtained).

ii) In the second stage, animals will be altered to allow them to respond to increased production of their own growth hormone. Other metabolic changes will be induced, if it can be shown that they are of economic importance. Research in this area is actively underway and application is expected within 5-10 years.

iii) The third stage is the really exciting phase. It involves the gene-splicing and bio-engineering of the genetic code of animals or plants to introduce specific attributes or traits. These are the so-called transgenic organisms. Apart from possessing improved production characteristics, we can expect these animals to have enhanced disease resistance etc.

B.C. cannot afford to be left out the picture in this regard, especially if it seeks to promote a high-tech image.

A suitable animal to benefit from Biotechnology is probably the salmonid fish. It took the poultry industry at least 40-50 years to develop an efficient meat-producing broiler chicken. The aquaculture industry in B.C. cannot wait that long to develop what is currently a wild fish into the most suitable type for fish-farming!

B. Pest and Disease Management Technology

There are innovative approaches to improve efficiency of production of both plants and animals. An important objective is a reduction in the use of toxic chemicals and drugs with concomitant improvements in environmental and food safety.

Technology developed under A and B above will be applicable to B.C. agriculture but will also be marketable abroad - both the technology and the instruments.

C. Plant and Animal Production Efficiency

The emphasis in respect to plant and animal production should be on efficiency rather than scale of production. Freer trade with the U.S. will place greater emphasis on this. In the Committee's view, we need to try and remove barriers to efficient production. Appropriate aims would be, for example:

i. improved reproduction in several species (e.g. beef breeding herds)

ii. better utilization of B.C. resources such as forage and forestry by-products as animal feeds

iii. identification of the causes and prevention of metabolic problems in several species, that are a constraint on efficient production.

iv. increasing the growth of plants within the natural growing season in B.C. by genetics of otherwise, or increasing the length of this growing period by artificial light and heating in greenhouses.

2. New Products and More Efficient Food Processing Techniques

There are opportunities for advances in packaging, storage and distribution processes.

There is a need to concentrate on new (to B.C.) technologies which give rise to new products of high value (such as fine chemicals, enzymes, and proteins) or to new packaging or storage techniques for the agriculture and food sector.

In all the commodity plans of the present industry, marketing, increased market penetration, and new markets were emphasized. Product innovation is an integral part of any marketing plan and necessary to the industry's survival.

3. Food Safety, Environmental Protection and Waste Management

Food safety, environmental protection, and waste management are important for sustained agricultural production and continued soil and water conservation. Specifically, appropriate technologies for tillage mechanization, irrigation, waste treatment, and drainage, are needed.

4. Science Council Centres for Collaborative Studies

There is potential for the establishment of Science Council Centres of Collaborative Studies in specific areas such as new food product development, pest management technology development, agriculture and aquaculture biotechnology, and environmental protection.

These centres would bring together scientists, research associates, graduate students, and postdoctoral fellows from throughout the province to research, develop, and test new products and technologies in the designated area. As well, a centre would function as a repository of knowledge and a centre for the dissemination of knowledge in that area.

It is suggested that these centres be located at provincial universities. However, each centre might undertake and/or fund activity at other locations such as technology transfer work at industrial sites.

Funding by Science Council would be on a continuing basis with allocations being made annually to each centre.

On-line computer access to the data bases of each centre would provide a mechanism for direct dissemination of information to industry and to other interested groups such as Science Council.

These centres would raise the visibility of Science Council and would advertise the fact that British Columbia is a province committed to a forward-view of industrial development.

The recently announced B.C. Food Technology Centre at UBC is an example of such a centre. Appendix A provides details.

VIII. INDUSTRY INVOLVEMENT

The level of industry involvement in research and development in the sector in B.C. is low. This is partly because of the small size of production and processing units in B.C., and partly, in the case of supply and processing subsectors, a product of the "branch plant" syndrome. Market size in B.C. is another factor.

At the agricultural production level, a long history of federal involvement in production agriculture research means that private funding of research in the sector is largely without precedent.

The large number of relatively small producers of most crops and livestock products of agriculture means that it is difficult for any one producer to capture the gains of his investment in research. Competitive market conditions for many products of agriculture and fisheries means that this situation is likely to continue.

However, there are opportunities for the industry to participate more fully in the process of R & D in the province.

Identification of markets and new products by producers and/or processors is one opportunity.

Identification of new technologies and processes is another.

Producer input into research programs, reflecting the end use of a new technology, would be valuable.

The Committee recommends that the Science Council investigate further how industry participation in research and development in the province might be stimulated.

IX. FINANCING REQUIRED

Commitments

Current annual commitments by the Science Council of between $250,000 and $300,000 per year represent less than one percent of the R & D resource commitment identified in this report for the fiscal year 1987/88.

A significant commitment would be $ 1.0 million per year for applied research in support of the AGAR grants program as it is presently constituted with an additional commitment of at least $3 million per year for research programs of a longer term nature.

X. CONCLUSIONS

The Committee has examined the potential for Science Council to assist R & D in the agriculture and food sector of the B.C. economy over the period 1988 - 2000 and concludes as follows.

Competition

1. There will be an increasingly competitive market environment for the products of the agriculture and food sector of the B.C. economy over the period 1988 through the year 2000. This expectation has two consequences for the agriculture and food sector in B.C.

2. First, there will be a need for innovation and new product development in the sector.

3. Second, B.C. agriculture and food production, processing, and marketing operations will have to be increasingly more efficient.

4. These conclusions lead to a general conclusion that emphasis in scientific research and development in the period should be placed on areas of enquiry which, a priori, have the potential to

   a. create or develop new and innovative products in the sector, or,

   b. create significant increases in the technical efficiency of production, processing, or marketing of agriculture and food in the province

before the end of the century.

5. Research and development in pest and disease controls is a major area for emphasis under 4.b. above.

6. Biotechnology is an area for emphasis over the longer term.

Health and Safety

7. Safer food and a safer environment are, and will increasingly continue to be, major concerns of the public in B.C. This observation gives rise to a second major area for emphasis for R and D in the next few years.

8. Emphasis on research and development which has the potential to lead to safer biologically-based (rather than chemically based) production processes is likely to be of value in the period.

Environmental Protection

9. Procedures for better environmental protection and for the control of wastes and residues of chemical controls of agriculture and food production and processing will increasingly be needed.

Infrastructure of Science in the Province

10. The infrastructure for the teaching and training of agricultural and food scientists in the province has been depleted through several years of underfunding recently. This infrastructure needs to be repaired, restored, and upgraded to current Canadian, if not world, standards.

11. The Science Council should encourage and create an environment in agricultural and food science in the province which allows creative inquiry and some higher risk research in the pursuit of excellence in the fields of product innovation and production efficiency in B.C.

Technology Transfer

12. The traditional mechanism for technology transfer in production agriculture in the province is suffering from funding cuts. There is an opportunity for Science Council to support increased technology transfer in the agricultural and food sector in the province.

Science Council of B.C. Centres for Collaborative Studies

13. There is potential for the development of SCIENCE COUNCIL CENTRES of expertise and research activity in specific areas such as NEW PRODUCT DEVELOPMENT, PEST MANAGEMENT TECHNOLOGY DEVELOPMENT, AGRICULTURAL BIOTECHNOLOGY, AND ENVIRONMENTAL PROTECTION. These centres would not only raise the visibility of the activities of the Science Council in these particular areas, but would advertize the fact that British Columbia is a province committed to a forward-view of industrial development and maintenance of environmental quality.

RECOMMENDATIONS OF THE COMMITTEE

Research and development in the Agriculture and Food sector should build on British Columbia's natural advantages. Significant research and development will be required to capitalize on these advantages. Funding of agriculture research and of food processing research and development has consistnatly shown high returns on investment.

Innovations in the areas of primary production are important for the maintenance of a competitive and increasingly specialized agricultural industry. This industry makes an important contribution to the stability of the social fabric as well as the economic fabric of the province.

Innovation in product development both in the manufacture of new products and in the development of new technology for processing, storage, and packaging is of obvious importance for expansion of the economic base in the province and the creation of new job opportunities, particularly with the possibility of free trade with the United States.

Strategies for addressing the specific development requirements of the most of the many types of production (beef cattle, hogs, tree fruits, vegetables, berries, etc.) involved in the B.C. agriculture and food industry have been developed by industry taskforces consisting of producers and other industry personnel, B.C. Ministry of Agriculture and Fisheries officials, and Agriculture Canada officials. A list of the areas in which these strategies have been, or are being, developed is appended (Appendix B). Many of the resulting strategic plans (strategies) have been published. These plans describe each type of production's requirements for development, including, where recognized, the needs for scientific and technological developments.

The recommendations below relate to the broad areas of needs in the agriculture and food sector. These needs interrelate closely with those in the sectors of Aquatic Resources, Biotechnology, Manufacturing and Machinery, Informtaion technology, and Energy.

Research Areas

1. Applied research in the agriculture and food sector to develop innovative, high value products, and to develop packaging and storage processes which increase consumer satisfaction and convenience, add to product life, and increase market penetration.

2. Research with the potential to add to the efficiency of production in the area of biotechnology in primary agriculture and aquaculture.

3. Research in the areas of pest and disease management in primary agriculture and aquaculture.

4. Research towards increased efficiency of food processing and marketing.

5. Research into food safety.

6. Research on environmental protection and waste management, including soil and water conservation, for sustained productivity in the sector.

Implementation

1. Maintenance of the present Science Council of British Columbia Assistance Grants for Applied Research (AGAR) program with increased funding to enable more effective pursuance of research needed to develop new production and processing technologies and for technology transfer for its industrial exploitation.

2. Mechanisms for greater industry participation in research, development, and technology transfer in the agriculture and food sector.

3. Financial support for industrial testing of new equipment design, innovative plant procedures and new control instrumentation.

4. Funding activities that will lead to faster and more effective technology transfer in the agriculture and food sector.

5. Support for the maintenance and improvement of the infrastructure of teaching and research training in agriculture, aquaculture, and food science in the universities of the province.

6. Establishment of Science Council Centres for Collaboration in new product development, new pest and disease management technology development, agriculture and aquaculture biotechnology, and environmental protection.

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APPENDICES

APPENDIX A

Letter of Understanding

for

Research Collaboration

between

UNIVERSITY OF BRITISH COLUMBIA
Department of Food Science
248 - 2357 Main Mall
Vancouver, British Columbia
V6T 2A2

and

THE FISHERIES AND FOOD PRODUCTS BRANCH
B.C. RESEARCH
3650 Wesbrook Mall
Vancouver, British Columbia
V6S 2L2

March, 1987

Memorandum of Agreement

B.C. FOOD TECHNOLOGY CENTRE

The Centre is an organization of two partners who agree to participate co-operatively and jointly in research, development and technology transfer to service the food industry.

Partnership

The Department of Food Science, University of British Columbia and the Fisheries and Biotechnology Division, B.C. Research will be partners in a co-operative venture for providing research, development and technology transfer on a contract basis. Such a partnership will entail:

1. the co-operative participation of faculty members, staff and students of the Food Science Department, UBC and staff of B.C. Research,
2. the sharing of laboratory and pilot plant equipment when appropriate,
3. the distribution of contract funds to each partner as negotiated for each contract,
4. the equitable sharing of patent rights and license fees from any patents which may evolve from co-operative research and development between the two partners.

Objectives of the Centre

A. The Centre will provide food companies, government agencies and individuals with the following services:

- literature survey
- feasability assessments
- design of quality assurance programs
- technical assistance on food safety and toxicology
- product evaluation - biological, chemical, physical and sensory
- business management and marketing strategy
- assistance in applying for government grants and contracts for research and development, and technical staffing
- applied research
- product development
- process development
- engineering design of processes, equipment and plant layout
- waste management (air, water and solids handling)

B. The Centre will institute short courses and on-site training programs for upgrading the knowledge and skills of professionals in the field of food technology.

C. The Centre will publish periodically technical bulletins and newsletters.

D. The Centre will employ graduate and undergraduate students in Food Science to provide experience in applied research and product development. Thesis research of graduate students will be undertaken within the Centre.

Management of the Centre

The Centre will be managed by two Co-Directors. One Co-Director will be the Head of the Department of Food Science, UBC and the other will be the Head, Fisheries and Biotechnology Division, B.C. Research.

Co-Directors will be responsible for:

1. discussion with potential clients about proposed services
2. preparation of R & D service proposals
3. client relations
4. co-ordination of R & D service activities
5. preparation of R & D reports for clients

The Centre will be assisted by an Advisory Board made up of representatives from B.C. Ministry of Agriculture and Food, Agriculture Canada (Food Processing Section, Summerland Research Station), Fisheries Council of B.C., Western Food Processors Association and the Dairy Council of B.C.

Financial Arrangements

1. One or both Co-Directors will discuss proposed services with potential clients and will estimate the fee structure for such services.

2. With each contract, one of the Co-Directors or his designate will accept the role of principal investigator and will manage the financial affairs. The other Co-Director or his designate may act as a Co-investigator (sub-contractor) with financial support in the form of a negotiated sub-contract.

APPENDIX B

APPENDIX B

List of Commodities and Types of Production in the B.C. Agriculture and Food Sector for which Strategic Plans have been prepared or for which Strategic Plans are being prepared.

LIVESTOCK, POULTRY, AND FISH

- Beef
- Dairy
- Hogs
- Poultry
- Aquaculture
- Apiculture
- Game Animal Farming
- Commercial Fisheries

FRUITS AND VEGETABLES

- Raspberries
- Strawberries
- Blueberries
- Seed Potatoes
- Mushrooms
- Asparagus
- Processing Vegetables (Peas, Beans and Corn)
- Fresh Vegetables
- Tree Fruits
- Grapes and Wine

CROPS

Cereals Grains and Oilseeds

Feed Grains

Forages

Forage Seeds

Greenhouse Products

FOOD PROCESSING

ORNAMENTAL PLANT NURSERIES

FLORICULTURE (Cut Flower Industry)

SOIL AND WATER

SUMMARY OF RECOMMENDATIONS

FROM ALL SECTORS

AGRICULTURE AND FOOD PROCESSING

PRIMARY AGRICULTURE
- ROLE OF AGRICULTURE CANADA
- VERY SMALL AVAILABLE LAND BASE

SECONDARY MANUFACTURE
- POTENTIAL GROWTH AREA

FOOD PROCESSING
- POTENTIAL GROWTH AREA

RECOMMENDATIONS

- INTERFACE WITH BIOTECHNOLOGY
  - DISEASE CONTROL
  - GENETICS
  - WASTE MANAGEMENT
- VALUE ADDED
  - FOOD PROCESSING
- INCREASE PRODUCTIVITY
- INCREASE INDUSTRY INVOLVEMENT
  - CO-OPERATIVE RESEARCH

AGRICULTURE AND FOOD PROCESSING

RECOMMENDATIONS (CONT'D.)

- FUNDING FOR SECONDARY MANUFACTURE, FOOD PROCESSING
- RESEARCH ORGANIZATIONS STAFFING AND EQUIPMENT
- GENERAL AWARENESS
- TECHNOLOGY TRANSFER

Science Council of British Columbia

Helping Make Tomorrow Happen in B.C.

AQUATIC RESOURCES

$750M INDUSTRY

AQUACULTURE - HIGH GROWTH
- SCIENCE ISSUES

RECOMMENDATIONS

- WATER QUALITY
  - SPECIFIC CONTAMINANTS
  - AQUACULTURE
- AQUATIC INSTRUMENTS AND DEVICES
  - INTERFACE WITH SECTOR
  - GROWTH AREA
- FISH HARVESTING
  - GOVERNMENT AND SOCIAL POLICIES
  - IMPROVEMENTS POSSIBLE
  - SHIP/SHORE COMMUNICATION

AQUATIC RESOURCES

RECOMMENDATIONS (CONT'D.)

- FISH PROCESSING
  - NEW PRODUCTS
  - BY-PRODUCTS
  - QUALITY
  - PACKAGING
- AQUACULTURE
  - INTERFACE WITH BIOTECHNOLOGY
    - DISEASE CONTROL
    - NUTRITION
    - GENETICS
    - WASTE MANAGEMENT
  - NETWORK OF EXCELLENCE

BIOTECHNOLOGY

EMERGING INDUSTRY - $12M

IMPACTS ON MANY SECTORS - FORESTS
- AGRICULTURE
- AQUACULTURE
- HEALTH
- WASTE MANAGEMENT
- MINING

NEED FOR STRATEGIC PLANNING, CO-ORDINATION

RECOMMENDATIONS

- FOCUS ON
  - DISEASE CONTROL
  - GENETIC IMPROVEMENT
  - WASTE MANAGEMENT

- STRATEGIC PLANNING - USE OF EXISTING COMMITTEE

- LONG TERM COMMITMENT OF FUNDING

- RAISE FUNDING FROM $10M TO $30M - 5-10 YEARS

BIOTECHNOLOGY

RECOMMENDATIONS (CONT'D.)

- STRATEGIC RESEARCH, TRAINING, SCHOLARSHIPS
- INDUSTRY/UNIVERSITIES INTERACTION
- REVIEW FACILITIES NEEDS AND CO-ORDINATION

Science Council of British Columbia

Helping Make Tomorrow Happen in B.C.

ENERGY

MAJOR RESOURCE OF PROVINCE

DEPENDENCE OF OTHER RESOURCE SECTORS

OIL - IMPORT TO B.C.

NATURAL GAS SURPLUS

RECOMMENDATIONS

- OIL & GAS
  - DEVELOP UNDERSEA ROBOTICS
  - PREPARE FOR SWITCH AWAY FROM OIL
  - NATURAL GAS DIESEL ENGINE CONVERSION
- COAL
  - DEVELOP CAPABILITY TO ANALYZE COALS
  - BENEFICIATION & TRANSPORTATION
  - ALTERNATIVE USES

ENERGY

RECOMMENDATIONS (CONT'D.)

- WOOD RESIDUE AND BIOMASS
  - CONTINUE DEVELOPMENTS - METHANOL, ETHANOL
- OTHERS
  - HYDROGEN
  - FUEL CELL

SCIENCE & TECHNOLOGY ENERGY FOCUS

- CENTRE FOR ENERGY STUDIES
- BUILD EXPERTISE
- UNDERTAKE TESTS
- NATURAL GAS
- LONGER TERM ITEMS

FORESTS AND FOREST PRODUCTS

GROWTH AREA

MOVING TO VALUE ADDED PRODUCTS

RESOURCE DIMINISHING AND MORE EXPENSIVE

WORLD-WIDE COMPETITION

DEPENDENCE ON SCIENCE & TECHNOLOGY

ADVANCED MACHINERY AND SYSTEMS

PEOPLE NEEDS

RECOMMENDATIONS

- OVERALL CO-ORDINATION FOR SCIENCE AND TECHNOLOGY
- ADD VALUE
- IMPROVE PRODUCTION FOR RESOURCE

FORESTS AND FOREST PRODUCTS

RECOMMENDATIONS (CONT'D.)

- RAISE TECHNOLOGICAL AWARENESS AND COMPETENCE
  - RESEARCHERS
  - 'RECEPTORS'
- TECHNOLOGY TRANSFER
- USE OF ADVANCED SYSTEMS, TECHNOLOGIES AND MACHINERY

INFORMATION TECHNOLOGY

$1 BILLION INDUSTRY

11,500 PEOPLE

25%-50% ANNUAL GROWTH

RESOURCE INDUSTRIES/INFORMATION TECHNOLOGY

PEOPLE NEEDS

CO-ORDINATED ACTIONS

RECOMMENDATIONS

- ENHANCE RESOURCE INDUSTRIES BY ENHANCING THE INFORMATION TECHNOLOGY INDUSTRIES
- COMMIT TO INFORMATION TECHNOLOGY
- MARKETING, MANAGEMENT, TECHNICAL PEOPLE
- CO-ORDINATION AND PLANNING ROLE
- INFRASTRUCTURE AND SUPPORT

MANUFACTURING

IMPORTANCE TO PROVINCE

4,000 COMPANIES - 40 LARGE

LACK OF TRAINING

DIFFICULTIES OF LOCATING PARTNERS

TECHNOLOGY TRANSFER - SMALL COMPANIES

RECOMMENDATIONS

- STRATEGIC PLAN - 'CHAMPION'
- BIOMEDICAL DEVICES
- EDUCATION AND TRAINING
- TECHNOLOGY CENTRE
- RESOURCE INDUSTRIES - ROBOTICS
- NETWORKING
- CAD/CAM
- FUNDING

MINING, MINERALS, METALS

NEEDS

- INDUSTRY INVOLVEMENT
- NATIONAL CO-ORDINATION
- FOCUS ON R&D
- RAISING AWARENESS

RECOMMENDATIONS

- R&D CO-ORDINATOR FOCUSSED ON B.C. NEEDS, NATIONAL INTERFACE

- INDUSTRY CHAIRS - ADVANCED MATERIALS

- CENTRES OF EXCELLENCE:

  - ADVANCED MATERIALS
  - INDUSTRIAL MINERALS
  - GEOLOGICAL EXPLORATION
  - RARE & PRECIOUS METALS

EMERGING THEMES

- BUILD ON EXISTING COMPANIES, ORGANIZATIONS AND INDIVIDUALS
- ORGANIZED STIMULATION OF INTERACTION AND PLANNING WITHIN AND BETWEEN SECTORS
- RESOURCE INDUSTRY FOCUSSED, TECHNOLOGY DRIVEN CENTRES OF EXCELLENCE
- VALUE ADDED PRODUCTS FROM RESOURCES USING TECHNOLOGY DEVELOPED IN B.C.
- DEVELOP THE MARKETING, MANAGEMENT AND TECHNICAL TALENTS OF OUR PEOPLE
- EFFECTIVE USE OF SIGNIFICANTLY MORE R&D SPENDING

Science Council of British Columbia

Helping Make Tomorrow Happen in B.C.